System Perspective on Service Provision: A case of community-based washing centres for households

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Abstract

Life cycle management has often paid more attention to environmental impacts of products than services. In this paper, we devote more attention to evaluating environmental impacts of product-services by investigating community-based services (CBS). Since they are provided close to the end-consumer, CBS have a strong role in shaping consumption patterns and a certain potential in reducing associated environmental impacts. The study aims at investigating the institutional framework and the potential for reducing life cycle impacts through development and provision of community-based services that substitute function delivery by a single product. In order to fulfil this goal, a case of community-based washing centres in Sweden is studied from historical, institutional and business perspectives and environmental outcomes of CBS are qualitatively and quantitatively evaluated. The design of the services is discussed following the product service systems framework.

The results show that assuming the same behaviour in both cases, community-based washing centres have lower resource consumption, which stems from high performance characteristics of the installed equipment. The study also estimates the total saving on national level from using shared washing facilities. However, it is demonstrated that behavioural aspects are very important in determining the environmental soundness of service solutions. The paper proposes that energy savings could be even larger if the laundry services would be provided by businesses and/or the users would be better informed about optimisation possibilities of their washing operations. A number of recommendations are also provided on how energy consumption of washing activity can be reduced. Finally, the paper discussed the importance of specific policy interventions in developing more sustainable services.

Key words: Product service system, life cycle management, energy consumption, institutions

Introduction

Studies demonstrate that many eco-efficiency improvements in production processes and product design are undermined by increasing consumption levels associated with household consumption. The contribution of households to overall environmental impact is on a rise and will intensify in the coming 20 years. For example, in OECD countries, energy use grew by 36% from 1973-1998 and is expected to grow by another 35% by 2020. Likewise, by 2020 the total motor vehicle stock will grow by 32% (personal cars represent 75% of it) and municipal waste is projected to grow by 43% (OECD 2001; OECD 2002). Therefore, it is important to find ways for reducing consumption-related environmental impacts.

One of suggested ways for reducing these impacts is to substitute functions and services provided by individually-owned products with systems of shared use or services delivered directly to households by various actors (Behrendt, Jasch et al. 2003). Community-based service solutions can contribute by more efficient utilisation of product functions, faster replacement of obsolete and inefficient products and technologies and improved management of negative environmental impacts induced by consumption. Furthermore, community services generated and consumed locally may be able to better satisfy consumer needs and at the same time reduce transport-related environmental impacts. The environmental impact of household functions can also be optimised by environmental design of CBS. In order to evaluate environmental impacts and suggest design improvements of CBS a Life Cycle Management (LCM) concept can be used, which traditionally has been applied to evaluating and reducing environmental impacts of products rather than services. In this paper we use the LCM concept for comparing environmental impacts of two systems, one of which is washing in a privately owned washing machine and another one is washing in a community-based washing centre.

To take into account rebound effects stemming from increased use of products (consumption levels), it is important to investigate how products and services are being used by households (consumption patterns). Since consumption patterns of households are to large extent affected by existing institutional frameworks, both normative and regulatory settings of community-based services should be studied.

Thus this paper aims to investigate the potential for reducing lifecycle environmental impacts through the development and provision of community-based services that substitute product ownership based delivery of function. In the paper the institutional framework and environmental impacts of community-based services are studied, taking a specific case from Sweden. Community-based washing centres (CBS) are services of particular relevance for this inquiry, since they are well embedded in the Swedish society, have a long history of institutional support and infrastructural development, and a certain possibility to reduce environmental impacts associated with washing function performed in households.

The disposition of the article is as follows. Section 2 presents a conceptual framework of product service system used in presenting and discussing the case of community-based washing centres from Sweden. Section 3 discusses the institutional context and Section 4 describes the organisation of product service system around communal washing services following a four-component model. Section 5 is devoted to an evaluation of environmental profiles of washing centres versus private washing machines. Section 6 discusses possibilities for environmental improvements and Section 7 discusses the success factors of such service systems.

1. Framework for Evaluation and Methodology

The design, environmental and institutional features of the case are discussed in accordance with the Product Service Systems framework (Figure 1), focusing on four key components of product-service systems – products, services, infrastructure and actors networks.

The environmental outcomes of CBS are evaluated both qualitatively and quantitatively and particular features of the service are discussed in terms of life cycle management. The intention is also to learn more about the aspects of organisational structure, actor involvement and context factors that led to a broader deployment and use of community-based washing centres in Sweden.

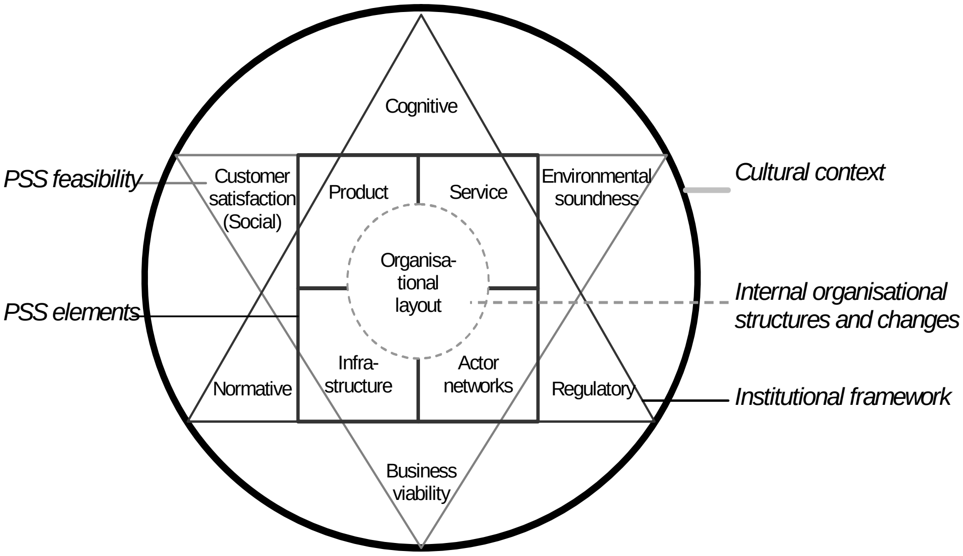

Figure 1 PSS framework (Mont 2004)

The main research methods used in the study were literature review, visits to community-based washing centres, interviews with community planning authorities, equipment providers (Electrolux), the first housing organisation that introduced washing centres in 1920's (HSB), historic statistical data on consumption and demographics, as well as consultations with the Swedish Energy Agency on efficiency standards of washing and drying equipment.

2. Institutional Context of Community-based Washing Services:

Historical Context

The development of washing services is an example of a social development that was greatly affected by ideological and political influences. In the first half of the 19th century, a clear trend in household work was towards buying external services. From the middle of the century, the opposite trend could be seen – towards so-called self-service economy (Cronberg and Sangregorio 1978). According to Gershuny, in the self-service economy instead of buying external services for household work, people can perform household tasks as efficiently due to availability of technological solutions (Gershuny and Miles 1983). Also partly it became an issue of cost. With the decreasing costs of products and increasing costs of labour it became more economically feasible to shift self-services.

At the beginning of 20th century, washing was done manually at designated places. In cities, water was available in apartment buildings, so that people could wash in their flats. However, for big washing tasks there was still not enough space. Therefore, there was a need for some communal premises, such as laundries, washing rooms and wash-houses (Cronberg 1987). Very few apartment buildings actually had washing rooms for their tenants. Some studies show that in 1943 only 10% of houses in central Stockholm had access to washing rooms that were used by 250 households (Rosén 1993). In that case they were equipped with rinsing bowl and boiling wall, in which water could be boiled on the open fire in an immured bowl.

First in 1950s, real estate companies started to regularly equip their newly built houses with washing rooms and washing machines (Mitchell 1993). HSB, a real estate company, was the first one in Sweden to equip washing rooms with machines (Rosén 1993). The alternative was communal wash-houses, as by 1948 only 1% of all households could afford own washing machine (Kjellman 1989). It was calculated that by 1958, around 30% of flats had access to this type of washing facilities (Hagberg 1986).

Still, according to an official report, in 1955 70% of washes were done manually (Henriksson 1999). By the end of 1960s, already 80% of population had access to small washing centres, well equipped with automated washing machines. Out of these, less than half owned washing machine at home (Hagberg 1986). The development went not towards big wash-houses, but towards having washing facilities in apartment buildings. However, capacity of these places was not sufficient, so households could wash only once a month or even every other month (Henriksson 1999).

In the last three decades of the 20th century, majority of people wash themselves either with own washing machines or at the communal washing facilities situated close to households. Henriksson suggests that we wash more often and smaller amount of cloth per time, but the total amount of laundry is constantly increasing. Reasons to this increase will be discussed in the section on environmental impact of washing (Henriksson 1999).

Regulatory support

In Sweden, the issue of establishing washing centres was first given attention during the 1930s and the 1940s by the Swedish Housewives' Association and other women organisations in the context of easing the burden of housewives. The discussion was of both political and socio-economic nature – whether to promote women as workforce or as housewives (Rosén 1993). Following the chosen course towards integrating women into the work market, the question of assisting women in household activities got regulatory support. Hagberg (1986) suggests that it was also an ethical issue – to help women with the most strenuous household activity of the first half of the 20th century. (Hagberg 1986)

During 1939-1946, a direct financial support was given to cooperative washing centres in countryside (Kjellman 1989). By the end of that period, approximately 70 such centres were established in Sweden (Henriksson 1999). In order to get financial support, cooperative washing centres had to be equipped with washing machines and be driven as economic entities, with participants being share subscribers.

Some of the cooperative washing centres developed into proper service companies because they were often situated far away from the households and many users found it difficult to use them as self-service places (Kjellman 1989). In 1947, an official report "Collective washing" advocated collective way of doing laundry (SOU 1947:1 1947). It did not however provided clear guidance regarding which forms of washing should be promoted in countryside and in cities. A new official report from 1955 preferred self-service washing centres and external washing services to washing in one's home. Rosén (1993) implies that this report promoted more technologically and economically efficient solutions. At the beginning of 1960s, the countryside households started using private washing machines and in cities communal washing centres were spreading, while commercial washing facilities became more and more marginalised (Henriksson 1999).

Later, a number of authorities, such as Consumer Protection Agency, Swedish National Board for Industrial and Technical Development, The National Board of Housing, Building and Planning followed up the development of communal washing centres (CWC) in a range of studies and provided a number of recommendations on how these centres should be equipped, how they should be designed so that households would be satisfied.

Current Swedish legislation about rental and owned flats provides guidelines about baseline equipment and location of CWC and sets the standard that needs to be fulfilled by organisations that build and own them. The Association of Tenants and the Society of Tenant-owners also provide recommendations on accessibility and availability of CWC for newly built and existing apartment buildings and areas of smaller housing. The Energy Authority and other organisations also provide guidelines and advocate the instalment of energy-efficient equipment in the centres.

In 1989-1990, a special Secretariat for promotion of efficient use of energy at the Swedish National Board for Industrial and Technical Development (NUTEK) was established. In 1991 it organised a competition among manufacturers for developing energy efficient washing machine specifically for communal washing centres. The Electrolux model Wascator won the competition and was guaranteed to sell these machines to over 100 washing centres (NUTEK 1995). The Secretariat provided subsidy to the first 100 washing centres that would like to upgrade their equipment. The competition had wider effect on the entire industry too and many equipment manufacturers followed the trend towards more energy efficient equipment.

Clearly the political preferences towards communal washing centres played against commercial washing services and therefore the manufacturers concentrated on improving efficiency of production and on product, rather than on developing services (Kjellman 1989).

Normative settings

The patterns of consumption of products or services are also greatly affected by the prevailing normative settings. For example, the degree of cleanliness and consequent washing temperatures and frequency of washing are affected by societal standards of cleanliness (Chappells, Klintman et al. 2000). Each of us has own understanding about how clean we want our cloth to be. These standards however are not only set by individual preferences; they are shared and shaped by people. When using machines, people reproduce standards of behaviour that accompany material artefacts. These standards are learned by people in the course of life and include personal financial and time resources to be spent on activity, labour efforts, conventions about proper dressing and social rules about personal hygiene.

Patterns of washing greatly affect environmental impact of washing and depend on the socio-economic status and employment situation in the household. For example, people with higher education tend to wash less. One adult present at home all day (not working) tend to wash more. There are also differences between old and younger generations. Older people tend to wear cloth longer and then wash them with higher temperature and with full machine. Younger generation separates cloth in many fractions and does not usually fill the washing machine, but usually washes with lower temperatures (NUTEK 1994). So the total energy use is approximately the same.

Media and role models affect these standards and can either sustain or undermine them. For example, a visit of the Swedish Queen Sylvia to a communal washing centre in Rinkeby, Stockholm clearly increases prestige of this particular and all other communal washing centres (Carlsson 1999).

While in the early years, launderettes and washing services were the economic necessity, their role changed in the modern days. Owning a washing machine has long ago seized to be a luxury for many families and today it corresponds to less than 5% of the average net annual household income in Sweden. Nevertheless, a sizable share of households, especially those living in apartment buildings, opts to use shared launderettes. Even those families owning washing machines often use public launderettes to save time and the nuisance, as well as for practical reasons, e.g. for washing larger items such as carpets, pillows, etc.

There several main reasons for the increasing popularity of public washing facilities. The lack of space and excessive noise are perhaps the most straightforward, however, other factors are important too. There are several economic and demographic changes taking place in Sweden. One of the most relevant is that the number of households (especially young singles and elderly) has been steadily growing over the last decades. This is stimulated by the trends, such as children leaving their parents' home at a younger age, young people creating long-term partnerships and having children later in life, as well as ageing population moving to elder care institutions.

Other factors could be economic. In many tenant associations the users of shared launderettes are often charged a flat rate independent from the frequency of use. In this way all members of community share the costs of energy, water and facilities. In Sweden it is not uncommon that electricity costs are included in the total running expenses, which essentially does not provide strong incentives for energy saving. On the other hand, users of private washing machines are usually charged an extra fee (often at fixed rate) for having a possibility to install private washing equipment.

All the aforementioned factors contribute to the "normalisation" process of community-based washing centres. They have been embedded into the every day fabric of Swedish life and are considered a legitimate part of household.

3. Product-Service Organisation

According to the product service system framework (Figure 1), the main elements of a product service system are products, services, infrastructure and actor networks. These main elements are outlined in this section in relation to the community-based washing centres.

Product

A clear trend in communal washing centres is towards using semi-professional: they have the same or only slightly higher capacity than washing machines for private use, but often have state of the art choice of functions and options. They are usually more energy and water efficient than the washing machines for private use. These machines are built for easy management, shorter washing cycles, and provide a broader variety of different washing modes at different temperatures. The driers are also semi-professional with requirement for short dry cycles and easy use.

According to Swedish norms, each washing centre should serve 15 flats. Due to the fact that many flats install their own washing equipment, each commune decides how many machines should be installed to fulfil the need of households. It is usually calculated so that 25-30 flats could use one washing room (Rosén 1993). Each room usually contains 2-3 washing machines and drying equipment. The drying equipment consists usually of a drying tumble drier and a drying cupboard. In many washing systems that are situated outside the house, special drying rum is common. Users can dry their cloth on the clothesline and leave them over night. Depending on the economic situation in the commune, washing centres can be also equipped with centrifuge, ironing place for small items and a special equipment for ironing of bed linen.

Many new models of washing equipment today are gradually integrated with information technologies, which allow automatically determine required dosage of detergents based on water parameters, amount of wash and chosen washing cycle. This is important since some environmental improvements can be reached by saving of washing detergents. About 50,000 tons of washing detergents are used in Sweden annually and according to some estimates, this consumption could be lower by as much as 12 000 tons/year with optimal dosage of detergents. The main contributing factors for overdose are variety of detergents, lack of knowledge about proper dosage and incorrect estimates of water hardness (Konsumentverket 2003).

The recent trend in marketing washing machines is to address use-related environmental impacts and inform customers about energy and water consumption and consequently about potential savings. Electrolux AB was the first company in Sweden to present life cycle cost information to the final customers at retail places.

Service

Two general types of communal washing centres exist: a centre situated in a staircase of a building or a centre situated in a separate building in close vicinity to tenants. The first type is usually planned in multi-store houses, while the second type is used for one- or two-store houses. These two types define working regime of these washing centres. As machines are situated in house in the first case, there are usually certain restrictions of time of use (typically from 7.00 a.m. to 22.00 p.m.), so that no tenants are disturbed. Often community installs automatic system that switches on and off electricity in the CWC to keep the time regime. The CWC situated outside can work 24 hour.

Various types of booking systems exist. The simplest one is when households write down their names and time for which they will require washing room. In other places a special key system is being developed so that only one washing cycle can be booked at once. Other systems use telephone booking that is connected to each washing machine and a lamp is lighted after booking and lights for 20 minutes after the booking. In some CWCs, the time slots for washing are predetermined and regulated, e.g. from 7.00 a.m. to 10.00 p.m. with no more than 4-5 hours washing per household (HSB 2003).

The tenants generally can use a washing centre without additional costs, but sometimes a system is developed where people pay per every wash. Special rules are developed that prescribe that after having washed each user should clean the filters in a drier, mop the floor and in general leave the room in the same clean condition as it was. In order to keep track about how the rules are being followed, big washing rooms with up to 10 machines are usually broken up into smaller rooms. The tendency to build new houses with washing room in the staircase makes it easier for households to carry the laundry and also to keep the common places clean.

Future scenarios for communal laundry room are based on the ICT application as intranet system that allows obtaining real time information concerning free wash times and booking online. A special code could be used to enter the washing room. The machines are also upgraded and include the system for automatic dosage of detergent. The cost for the use of the laundry room, including the price of detergent, directly included into one's housing account. The different washing programmes of the machines will have different price and through that households will be encouraged to avoid unnecessarily high washing temperatures and use of washing programmes with pre-wash and main wash for not very dirty laundry. In this way potential savings in energy consumption, detergent use and effluent can be envisaged (Miljöteknikdelegationen 1999).

Infrastructure

The popularity of the communal washing centres is greatly facilitated by well-designed infrastructure and convenient access. The development of infrastructure has been facilitated by both governmental regulations, the initiatives from the housing companies and tenants' associations. For example, housing organisations started providing assistance with washing at home already since 1920s, when first uniformly designated washing rooms equipped with rinsing bowl and boiling wall were installed in multi-storied buildings. By the 1950s it became a practice for the real estate companies to regularly equip their newly built houses with washing rooms and washing machines (Mitchell 1993). In the last three decades of the 20^{th} century, majority of people wash either with own washing machines or at the communal washing facilities situated close to them.

Even the distance to the washing centre was taken into account in different guidelines. For example, it is suggested that the centres must to be situated in the close vicinity from households. The community based washing centres are required to be within 50-100 meters distance to all flats. Communal washing centres therefore became an integral part of the building plans, including construction of the facility, installation of electricity lines, water pipes and ventilation.

Since the majority of communal washing centres were available to tenants without extra payment (the costs are usually already included in the rent), energy saving is an important issue. For this reason many washing centres have centrifuges for efficient de-watering of laundry to save energy in tumble driers. Some washing centres even expand the infrastructure to include drying rooms where the laundry could be hung for a longer time. Sharing the costs of owning the facility made a more expensive semi-professional equipment affordable.

Networks and stakeholders

Very often household-oriented service solutions are developed without involving one or another relevant actor. Co-operation between the housing sector, community residents, external service providers, manufacturers and local authorities/governments is necessary in order to develop convenient and cost-efficient services. The principal actors in each of these actor groups include:

- Housing sector: housing organisations, housing service providers, construction companies and utility providers;
- External service providers: traditional profit-oriented service companies and/or renting, leasing and pooling commercial service companies that are not directly involved in the housing sector and are competing on the market;
- Local government: city planning authorities, authorities controlling housing standards and authorities responsible for social services;
- Manufacturers of equipment and products
- Residents: private property owners and tenants.

In the case of community-based washing centres, it is difficult for a product manufacturer to establish a local system of service provision. Therefore many equipment manufacturers look for potential local partners who can provide the service. For example, the Professional Appliances division at Electrolux AB assists initiators in starting a new launderette equipped with Electrolux equipment. In addition, the company offers installation and training, suggests layout of equipment location, supports with environmental permits, market surveys, contracts for maintenance and repair, guarantees, and financial schemes. In order to install the communal washing centre, producers are closely working with housing companies and tenant associations. Actually, collaboration starts even earlier, at the product design stage. According to Wascator, a branch of Electrolux AB that develops equipment specifically for washing centres, it is the customers who drive and shape the development of their products. Furthermore, it is often the service personnel of the local service provider who also contributes to the product development process.

Community-based washing services are open and flexible systems: several actors may participate in the service delivery, various levels of formality can link these actors and various life cycles of products become a part of the service delivery system. The main stakeholders are *businesses*, including equipment manufacturers and service companies, and *customers*, comprising real estate companies and tenants.

From the equipment manufacturer point of view, communal washing centres have two main customers: the housing company that builds the facility and the final users – households. Housing companies are usually satisfied with the service provided by producers or service companies, which install the machines, provide maintenance and replace the machines once they are old or could be upgraded. Caretakers of the housing communities usually check the cleanliness of washing centres, but the entire service is bought as a part of the washing solution from the producer or a service company. Households show varying degrees of satisfaction with communal washing: 70% are satisfied with the distance to the washing centre, 50% with the availability of washing time, 76% with the quality of equipment and only 40% are satisfied with cleanliness of the washing facilities (SIFO 2000).

Installation of the washing centre should of course be profitable for the housing community. Sometimes communities face tough choices when it comes to short-term economic savings and the possibility to reduce environmental impacts of washing centres in the long run. A choice between different types of washing machines may affect quality of washing, environmental parameters and economic efficiency. For example, a 4.6-kg machine has a special construction that allows using less energy and water than 3.4-kg machine. However, the price of the smaller machine is almost half the price of the 4.6-kg machine and it is up to each community to balance economic and environmental parameters (Rosén 1993). For households, the cost of washing facilities is not transparent, as it is usually included into the monthly rent. Households that install their own washing machines pay triple: for the communal washing centre, for own washing machine, and for electricity and water consumed by their own machine.

Economic benefits of centralised large-scale industrial service solutions vs. private household services are widely discussed in the literature. Heiskanen & Jalas mention a number of studies, which argue that private consumers doing home laundry have different kinds of costs, many of which are hidden or too small to be visible and thus are not always optimised. On the contrary, in industrial laundry installations economic optimisation is more likely, at least due to the scale of the costs (Heiskanen and Jalas 2003). Commercial operators are interested in reducing these costs (e.g. energy, water, detergents, etc.) and, therefore, tend to invest into large-scale equipment and state-of-the art technologies.

4. Environmental Implications of Washing Alternatives

To have a better insight into the environmental performance of the two consumption models of washing in the Swedish context, product ownership alternative was compared to the alternative of shared washing services. The comparison is based on the most recent typical data on washing machines, user behaviour and historic trends in Sweden reflected in statistical databases and information from housing companies and equipment manufacturers.

The lifecycle perspective on resources consumption

Community-based laundry facilities may reach lower environmental impacts than those originating from privately owned washing machine. For example, a study by the Swedish Local Investment Programme, showed that the typical electricity consumption for washing centres is 0.4 kWh/kg, while in the households this value is 0.8 kWh/kg (LIP-kansliet 2002). This likely to occur due to a possibility to use more technically advanced equipment, since the burden of higher investment can be shared in the community. One part of improvements stem from reduced hardware stocks, higher intensity of use results in shorter lifetime and faster upgrading of the equipment.

Other benefits can be reached from the potential of increasing washing efficiency in the washing centres, which is due to the access to larger-scale machines and equipment that is rarely used in home applications (e.g. IT-enabled washers, high-speed stand-alone centrifuges, heat exchangers, etc.). Furthermore, centralised facilities for community-based services could be operated by trained people, which saves time and provides additional employment. Figure 2 illustrates the results from an LCA study in terms of energy and water consumption and land, air and water pollution. It is obvious that most of the environmental impact from the life cycle of a washing machine takes place in the user stage, which stresses the point that both the choice of the resource efficient equipment and the optimal use of machines and detergents during operation are the critical factors determining the overall environmental profile of laundry services.

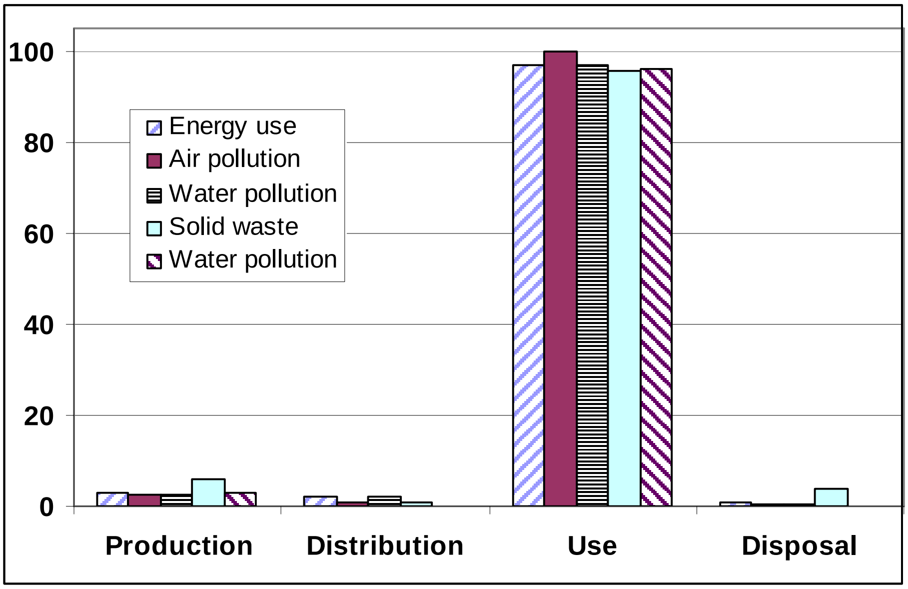

Figure 2. Lifecycle environmental impact of a washing machine (Lewis, Gertsakis et al. 2001).

Environmental impact of washing cloth depends to a large extent on both societal rules of cleanliness and on individual patterns of machine use. As other studies show, the environmental benefits of launderettes are not clear-cut. A lifecycle assessment study performed at the university of Amsterdam, for example, compared domestic washing and a washing in a public commercial launderette (Vrhunc 2000). The results of this study show that launderettes impose a larger overall environment burden than washing at home – around 35-45% in almost all impact categories. Overall energy consumption in the use phase was the largest influential factor, while the materials and energy used in the production of washing machine, and the transport of washing machine was negligible. In terms of energy consumption in the use phase, the study showed, that washing in a launderette is 30% more energy intensive than washing at home (Vrhunc 2000). Factors that contributed to a more favourable environmental profile of domestic washing were exclusion of thermal-drying at home and inclusion of car-travel to the launderettes. At the same time the study acknowledged that domestic washing looks less favourable from the environmental point of view when on-foot laundry delivery, more efficient laundry equipment and drying at home are included in the analysis (Vrhunc 2000).

In community-based laundry facilities all laundry deliveries are on-foot, and most of the basic maintenance (e.g. cleaning and tuning) is performed by the users or local personnel (e.g. a caretaker). In addition, the author did not consider the fact that many launderettes have high-speed stand-alone centrifuges, which allowed reducing energy demand for drying. Finally, most of private owners of washing machines also have drying equipment. Therefore, while the results of Vrhunc's study are valid for commercial launderettes, they are less likely to be applicable to community-based washing facilities (Vrhunc 2000).

Indeed, energy characteristics of laundry equipment (Table 1) indicated that energy efficiency increases along with the size of machines. The positive impact of large-scale operations can be illustrated by the results of a survey on performance characteristics in 34 industrial washing facilities performed by the European Partners for Environment (Table 1). The results of these studies and surveys indicate that washing using larger-scale equipment could potentially be more environmentally beneficial (given that it is used optimally) than smaller scale household machines.

Table 1. Comparison of average resource consumption in industrial and household-sized washing facilities and by large and small-scale washing machines.

	Whole facility		Washing machines	
Type of washing:	Industrial	Domestic	Industrial (*)	Domestic(**)
Water, l/kg	16 - 18	12-16	11.80	10.90
Electricity, kWh/kg	0.2 - 0.3	0.9	0.13	0.21
Source:	(EPE 2001)	See Table **4**	6.5-24 kg machines (Electrolux, 2004)	3-6.5 kg machines (Konsumentverket 2004)

* - based on characteristics of 6 models of "Wascator" available in 2004.

** - based on a survey of 266 models available in 2004.

In order to contribute to the discussion, we conducted a series of estimates on energy consumption by privately owned and community-shared laundry facilities.

Energy consumption in domestic laundries

In general, the annual amount of laundry per household has drastically increased since middle of 20th century along with the increased demands for washing standards. In Sweden for example, it changed from 290 kg in the 1930s to 500 kg in 1980s. Weight in this case does adequately describe the amount of washing, since textiles are becoming lighter thus total cleaned area of cloths has increased too (Henriksson 1999).

The increased amount of laundry gives some indication about potential consumption of energy, water and detergent and associated increasing environmental impact. According to some Swedish municipal surveys, about 60% of energy in a household goes to heating, ventilation and electricity. About 60% of electricity is used for white goods, such as refrigerator, freezer, oven and laundry equipment (Olsson 2003:9). Activities related to food preparation in a private house consume about 45% of all electricity. Energy consumption in laundry varies significantly. In private houses it is about 20% and in apartment buildings – up to 13-42 % of total electricity consumption (Hedberg, Dreborg et al. 2003:28).

An average person in Sweden washes about 200 kg annually. Calculating energy consumption using a bottom-up approach requires taking into consideration energy efficiency of laundering, which in turn depends on performance characteristics of equipment as well as user behaviour factors, such as loading rate and the choice of washing programme. For example, household washing machine with a maximum loading capacity of 3.5 kg is typically loaded by about 2-2.5 kg (Energimyndigheten 2003). This implies that an average person runs about 80-100 washing cycles per year, which, assuming two washes per laundry, results in 50 laundry days, i.e. about one per week. An average Swedish household consisting of 2.1 persons (SCB 2003a) then washes 400-500 kg laundry per year, which in our estimate implies a weekly laundry with around 4 machine-loads.

This estimate corresponds to a survey conducted by a Swedish association of municipalities KSL, according to which, a typical family uses a washing machine and a drying cupboard for about 4 hours/week. Some households instead of a drying cupboard use a tumble dryer, estimated use of which is 2 hours/week (KSL 2004). Similar conclusions have been made in other countries too. For instance, in 1993 in Germany, an average household washed 500 kg laundry/year (221 kg per capita) with on average 182 washing loads per year per household or 80 loads per capita (Table 2)

Table 2. Washing patterns in Germany (1993) and Sweden (2003)

	Germany		Sweden	
	Per household	Per capita	Per household	Per capita
Laundry weight, kg	500	221	420	200
Machine filling rate, kg	2.75	2.75	2-2.5	2-2.5
No. of washes per year	182	80	160 - 200	80 - 100
Source:	cf. (Bode, Pfeiffer et al. 2000)		(KSL 2004)	

Electricity consumption in a washing machine depends on maximum loading capacity, loading rate and the choice of washing programme, which determines temperature and the number of washing cycles. Specific characteristics of individual machines thus differ widely, but a market survey of laundry equipment in Sweden provided a picture about prevailing models. We analysed the data from Swedish Consumer Agency on 266 models and brands of washing equipment sold to Swedish households or for domestic use. The survey of equipment labelling by the European Energy Label showed that most of the washers are A-labelled and most of the dryers – C-labelled (Table 3).

Table 3. Numbers of different models of washing and drying appliance sold in Sweden according to awarded EU energy label (Konsumentverket 2005)

Energy label	Number of models	
	Washing equipment	Drying equipment
A	224	1
B	29	0
C	8	76
D	5	11
Total	266	88

The distribution by maximum equipment loading capacity is shown in Figure 3. For simplicity we assumed that a 5 kg machine is the most typical in an average Swedish household, while the typical machines used in communal laundry facilities have the loading capacity of 7-8 kg. Since out of 266 models only 14 had combined drying and washing function, we assumed that a typical Swedish household buys drying equipment separately.

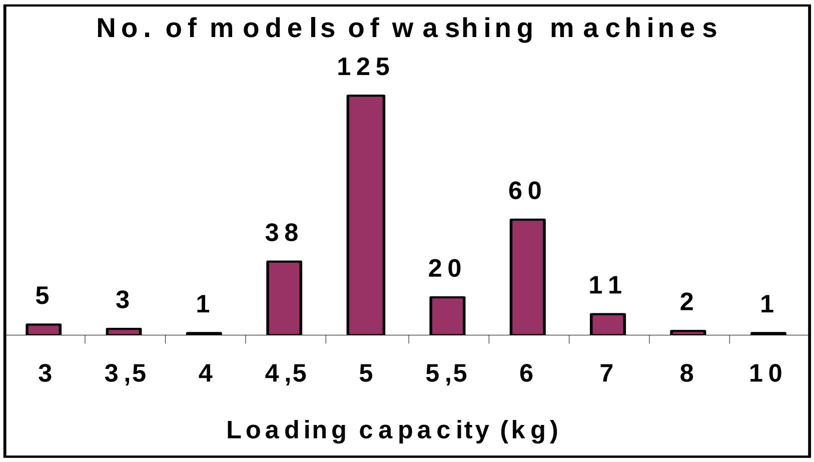

Figure 3. Distribution of different models of washers by loading capacity (Konsumentverket 2005)

The performance characteristics collected in Table 4 refer to the average electricity and water consumption grouped by loading capacity. It was assumed that all types of washing machines have more or less identical functionality and wash cotton fabric at a 60^{o}C temperature at full load. The average wash time is 2 hours 10 min, which includes two washing cycles and centrifuging. The table indicates that energy efficiency of washing machines increases along with their maximum loading capacity. Thus the typical 5 kg washing machine uses 0.21 kWh of electricity and 10.9 litres of water for each kilogram of laundry.

Table 4. Average performance characteristics for household washing machines and tumble dryers[1]

Washing machines			Tumble dryers	
Average load capacity (kg)	Water use litres/kg	Energy kWh/kg	Average max. load capacity:	Energy kWh/kg
3.0	15.2	0.25	5.2 kg (cotton)	0.81
3.5	11.8	0.22	2.7 kg (synthetics)	0.62
4.0	12.1	0.21	4 kg (average)	0.71
4.5	9.6	0.19		
5.0	8.4	0.19		
5.5	8.1	0.18		

Energy consumption of tumble dryers depends on the type of fabric. For example, synthetics require less energy to dry. For simplification, an average value of 0.71 kWh/kg for mixed fabric was derived based on the average data for typical equipment.

Given the aforementioned characteristics, the annual energy consumption of domestic laundry was calculated for different types of average households. While the average number of people in a Swedish household is 2.1, a distinction must be made between the number of people and the number of consumption units. The latter takes into consideration that the consumption volume of a statistical child is smaller than that of an adult. According to SCB, the average number for consumption units in a Swedish household is 1.62 (Table 5).

[1] The data is based on specifications from representative models of Electrolux, Kenny, Gorenje, Whirlpool, Bosh, Cylindia and LG. Konsumentverket (2005). Consumer purchasing guide. Stockholm, Konsumentverket.

Table 5. Average number of people and consumption units in different types of households (SCB 2003a)[2]

Household type:	Single with children	Single without children	Co-habiting with children	Co-habiting without children	Other co-habiting with children	Other	Average
# of people per household	2.60	1.00	3.90	2.00	4.70	2.80	2.10
# of cons. units per household	1.87	1.00	2.50	1.58	3.01	2.10	1.62
#of households (1,000s)	218	1,477	807	1,160	72	179	--

As it was indicated above, laundry equipment is not filled to maximum loading capacity. Since a 3.5 kg washing machine is typically loaded with 2-2.5 kg (Energimyndigheten 2003), we assumed a 70% average load factor and calculated resource consumption per consumption unit. Calculations of annual energy and water consumption in domestic laundry by family type are presented in Table 6. The total annual electricity consumption for a typical statistical family is about 0.3 MWh and water consumption – about 3.5 m^3 in case of optimal equipment loading. Assuming that laundry equipment is being only 70%-full and the energy and water consumption increases proportionally, the annual electricity consumption per households is close to 0.39 MWh and water – 4.6 m^3. The lowest resource consumption is among single households, and the largest – among families with children. The difference between the two extreme groups is 66%.

Table 6. Annual consumption of energy and water by family type

Household type:	Single w. children	Single w/o children	Co-habiting w. children	Co-habiting w/o children	Other with children	Other	Average
Amount of laundry, kg/year	374	200	500	316	602	420	324
Total use o water, m^3/year: *(5 kg machine, 10.9 l/kg)*	4.1	2.2	5.5	3.4	6.6	4.6	3.5
Energy use for washing, kWh/year *(5 kg machine, 0.21kWh/kg)*	79	42	105	66	126	88	68
Energy use for drying, kWh/year *0.71 kWh/kg mixed fabric*	266	142	355	224	427	298	230
Total electricity, kWh/y	344	184	460	291	554	386	298
Taking into consideration a 70% loading factor of equipment:							
Water, m^3/year	5.3	2.9	7.2	4.4	8.6	6.0	4.6
Total electricity, kWh/y	447	239	598	378	720	502	387

[2] Total number of households: 3,914,130

Energy consumption in communal laundries

Statistics on washing equipment ownership for different categories of households clearly indicate that the highest rates are among co-habiting households (Table 7.) It is also clear that households with children have higher ownership rates for washing equipment than those without.

Table 7. Ownership rates for washing machines (%) for different types of households in Sweden (SCB 2003b)[3]

Census year:	'90-91	'92-93	'94-95	'96-97	'98-99	'00-01	'02	'03	Average
Single without children	57.1	53.8	51.9	52.3	52.8	53.1	52.2	52.4	53.2
Single with children	65.8	63.6	61.9	66.1	67.2	66.9	64.3	66.6	65.3
Cohabiting without children	76.5	74.7	75.6	76.0	80.1	77.5	76.8	76.2	79.7
Cohabiting with children	90.7	91.2	88.7	88.6	88.9	88.1	89.8	89.4	89.4
Average:	72.5	70.8	69.5	70.8	72.3	71.4	70.8	72.5	72

Over the last 15 years, ownership rates among the youngest population have fallen by about 10%. This could be explained by an example of students leaving their parents creating own household in dormitories. Similarly, the rates have increased in the elder groups, while in mid-age groups the rates remained relatively stable (Table 8). Therefore, the most likely users of public washing facilities are young single households, families with small children and older population groups.

Table 8. Ownership rates of washing machines (%) by different age groups in Sweden (SCB 2003b).

Census year:	'90-91	'92-93	'94-95	'96-97	'98-99	'00-01	'02	'03	Aver.:
Age 16–24	69.8	64.2	62.7	62.7	59.4	61.4	59.1	58.8	62.3
Age 25–34	67.3	63.5	59.0	58.3	60.1	54.9	56.9	55.6	59.5
Age 35–44	82.7	81.6	79.8	78.7	81.5	79.1	80.8	78.8	80.4
Age 45–54	83.0	83.8	82.0	81.8	82.1	82.1	80.6	78.1	81.7
Age 55–64	78.5	75.9	77.7	77.9	81.7	80.8	78.1	81.0	79.0
Age 65–74	69.2	67.7	69.7	73.5	75.7	72.7	76.3	77.0	72.7
Age 75–84	53.6	55.2	55.8	58.4	67.0	65.8	64.3	64.1	60.5
All groups average:	72.0	70.3	69.5	70.2	72.5	71.0	70.9	70.5	71

[3]SCB (2003b). Tidsanvändningsundersökningen (in Swedish). Survey of time use. Stockholm, Sveriges centralstatistiskabyrån (Swedish Central Statistical Bureau)..
See Table MT7: Access to own washing machine for 16-84 year olds. Available on-line.
URL: http://www.scb.se/statistik/LE/LE0101/1980I01/MT703.xls. Retrieved 2004-12-06.

To calculate energy and water consumption in community-shared launderettes we used data of washing patterns in the Swedish household along with performance characteristics of typical equipment, assuming cotton wash at temperature 60°C with two washing stages. Differences in power consumption per one-kilogram laundry in domestic and public washing facilities are illustrated in Table 9.

Table 9. Washing characteristics for household- and launderette-based laundries (based on data from Electrolux AB).

Type of laundry:	Household-based	Launderette-based	
Typical max. load capacity:	5 kg	7-8 kg	
Typical loading capacity:	3.5 kg	4.6-5.3 kg	Difference
Electricity (kWh/kg)			
washing machine:	0.21	0.13	38%
tumble dryer:	0.73	0.48	34%
drying cupboard:	0.82	0.76	7%

In the latter, washing machines and tumble dryers are more energy efficient by about 35%. This is an indicative figure suggesting that using community washing centres results in significant energy savings. This conclusion is valid given that public washing facilities are not abused and an optimal laundry is performed (i.e. full loads and moderate washing temperatures).

5. Possibilities for Environmental Improvements

From our estimations it follows that washing in communal launderettes provides an energy saving potential in the order of 30% only due to the use of more resource efficient professional equipment. Even more can be saved if professionals, who can optimise loading rates and the use of detergents, handle the equipment. Loading machines fully and washing with lower temperature are very effective measures, which according to some studies, can save up to 25% of energy (Shanahan and Jonsson 1995). For example, Eco-Express reports 56% reduction of energy use, as well as a considerable reduction of detergent use (Hertwich and Katzmayr 2003).

The positive environmental potential of washing in a washing centre in comparison with washing at home is more likely, if low energy options are used for drying. The negative side of using launderettes is the use of tumble-driers instead of clotheslines, which might negate the positive environmental effect of common launderettes. High-speed tumble-drying as well as ironing are the most energy intensive steps in a laundry and so is car driving to a commercial launderette. Installing local facilities equipment with heat exchangers and naturally ventilated drying rooms are examples of measures to curb high energy consumption in launderettes.

Studies indicate that the largest environmental potential can be achieved when product life extension strategies are combined with product modification (Slob, Perdijk et al. 1997) cited in (White, Stoughton et al. 1999; Zaring, Bartolomeo et al. 2001). For example, in 1997 a project on sustainable washing of clothes showed that factor 3 improvements could be reached in domestic washing technology in terms of water, energy and detergent consumption by the year 2025 (van den Hoed 1997). The same factor 3 was possible to obtain in terms of energy consumption from a community-based washing centre or a large laundry. However, higher factor improvements, up to factor 10-16, could be reached due to efficiencies of scale and through reusing/recycling of water and detergent (van den Hoed 1997). This data confirms the need for systems approaches that allow high levels of improvement.

One clear benefit from using communal laundries is reduction of equipment stock and faster upgrading of hardware. The typical lifetime of privately owned washing equipment is often 15 or more years. It is however recommended to change the equipment at least every 10-12 years, since new, more energy efficient, models become available on the market (Energimyndigheten 2004). An example for these could be washing machines with dual water connection – one for cold and one for hot water. This allows reducing energy consumption for heating the water with electricity, which is a prevailing technology in many current machines.

The equipment used in shared washing facilities is used much more intensively and has a much shorter lifetime (typically 5-6 years). Furthermore, public launderettes typically have specialised equipment, such as stand-alone high-speed centrifuges, which are rare in domestic facilities. Drying equipment uses more energy than washing, and therefore the use of centrifuges before thermal drying allows a significant reduction of energy consumption.

Historic records on energy consumption in Swedish households show a significant reduction of energy consumption after the 1970s, when after the energy crisis a more energy efficient equipment appeared on the marker. A study (cf. Carlsson-Kanyama and Lindén 2002:30) of an average private Swedish house showed a two-fold improvement of energy efficiency from the baseline of the 1970s (Table 10).

Table 10. Comparison of energy efficiency of household appliances in Sweden before and after 1970

Household appliances	pre-1970s equipment	post-1970s equipment
Heating	20,000	11,600
Warm water	6,500	3,000
Refrigerator and freezer	1,700	400
Washing and drying equipment	1,500	600
Dishwasher	500	100
Electrical stove	1,000	700
Lighting	1,300	500
Other	1,000	500
Total	33,500	17,400

Energy improvements are taking place also today. For example, one of the R&D centres of the Hitachi Corporation compared design factors (washing capacity, power, etc.) and operational performance indicators (resource consumption) of two types of washing machines for domestic laundry (Table 11). The lifecycle impact related to generation of greenhouse gases was calculated using resource efficiency calculation methodology developed by the Wuppertal Institute in Germany (Schmidt-Bleek 1998).

The case study on washing centres provided a number of interesting lessons. Estimates on energy consumption in the two service scenarios – washing at home vs. washing in communal facility – indicated that 30% energy savings are attainable just in the user phase. Furthermore, hardware stock is reduced and the equipment is upgraded faster. This leads to environmental savings in the upstream lifecycle stages and facilitates increasing service quality by providing access to the latest state of the art technologies. The latter is an important factor for raising total consumer utility and promotes a wider acceptance of service solutions.

At the same time, servicising solutions do not always lead to environmental benefits. As it was discussed in the case study, consumer behaviour and structural aspects of service system can often create rebound effects reducing or negating the positive outcomes. The examples of these are the potential misuse of service solutions when cost incentives are not present or when costs are hidden (*e.g.* the use of communal washing centres "free of charge"). The example of structural aspects could be the necessity to add additional services in order to have access to the primary service (*e.g.* driving a car to a public launderette when the distance is too long).

Table 11. Comparison of performance characteristic of two products (Hitachi 2003)

Product	Washing machine KW-B483 (without a built-in dryer)	Washing machine NW-8CX (with a built-in dryer)
Year of manufacture	1990 (lifespan 6 years)	2003 (lifespan 6 years)
Washing capacity (kg)	4.5	8.0
Product weight (kg)	34	41
Recyclable m. weight (kg)	18.3	32.2
Resource use in operation		
Power consumption (Wh)	125	54
Water use per 1 year (m^3)	430	70
Detergent for 1 year (kg)	72	118
Greenhouse gas discharges (kg-CO_2 equiv./machine)		
Production stages	56	79
Transportation	4	6
Use stage	175	68
Return / recovery	11	16
Total	246 kg CO_2-equiv.	169 kg CO_2-equiv.

In addition, environmental gains may be short-lived, as they may be difficult to sustain over a longer time period if economic prerequisites are not right. Today many housing communities do not charge an extra fee for the laundry services provided in the communal washing centres (the costs are included in the monthly fee). Therefore, tenants have no clear financial incentives to optimise their laundry patterns. Even a small fee would facilitate a more efficient use of machines and laundry time. Furthermore, an effective energy saving measure in public or community-owned washing centres is a separate payment system for washing and drying. Preferably the users should have an access to other drying facilities, such as a drying-room or non-thermal dryers.

Furthermore, an economically viable and environmentally beneficial service solution may not be accepted by the final consumer, if it does not provide more total utility in comparison to the traditional household consumption systems based on product ownership. It may be cost effective to use a communal service solution, but inconvenient in terms of on-demand availability, accessibility and comfort of use. For example, a communal laundry facility could have efficient equipment, but be overbooked and/or be too complicated to use by ordinary people. Or household behaviour may lead to inefficient use of washing equipment. For example, data provided by Rosén (1993) show that households that used their own washing machines were washing less number of washing cycles per week, than households that used communal washing centre (Rosén 1993). It seems that people use their own private machines more economically than common washing machines. This is an example of potential rebound effect that may lead toward people choosing higher temperatures and longer than necessary washing cycles just because the service is available and not linked to direct costs of using the equipment.

Addressing these issues requires systemic approach integrating entrepreneurial, environmental, social and political considerations when designing sustainable service solutions.

6. Success Factors for Consumer Acceptance and Service Use

There appears to be three main conditions that need to be fulfilled if consumers are to use sustainable services. These are *total utility*, *costs*, and *information*.

The notion of *total utility* is closely linked to a set of tangible and intangible results. The former refers to physical service outputs, such as *e.g.* clothes washed, carpets cleaned, miles driven, etc. The latter refers to emotional perceptions that increase the user's satisfaction and well-being described *e.g.* by the level of comfort, positive impressions or time saved. It is important not only to maintain consumer satisfaction, but also to do it in a way that ensures economic soundness of service activities, especially in comparison to the traditional product-based solutions. For example, laundry in community-based washing centres should be pleasant, satisfactory and cheaper (at least on the long run) than domestic laundries. For this reason communities install a greater variation of different equipment of different sizes.

Maintaining high level of order in the washing centres is a challenging, but crucial issue to reach consumer acceptance. Communal washing centres are known to be one of the major places for arguments between the neighbours over the booking times and quality of maintenance after use. An online question "What irritates you most in your washing centre" asked by newspaper Aftonbladet got around 10,000 answers, which showed that 74% of users are irritated when time bookings are not respected.

Distance to the washing facilities in fact is one of the main factors determining the rate of use. Owning a washing machine is economically feasible for many households in Sweden and many families may chose to install private laundry equipment rather than using shared facilities, if the distances are too great or time availability is too low. According to the Swedish Local Investment Programme, the following percentage of households in apartment building use communal washing facilities: 50% - if they do not have to leave the building; 40% - if the facilities are located in an adjacent building, and 25% - if the facilities are located farther than an adjacent building (LIP-kansliet 2002). Therefore, strategic placement of laundry centres is extremely important.

The *total cost* of a service must be transparent and must not exceed the cost of traditional product ownership-based alternatives. In other words, the service should not cost more than products that fulfil the same need. If the service solution costs more, then the monetary value of the total utility received must outweigh the costs of product alternatives.[4] Commercial (and for that matter community-owned) laundries must have at least comparative or lower costs and

[4] For example, modern household machines take on average 5 kg at maximum load and cost ca. 1,000 USD (without installation costs). The average lifetime is 10-15 years or around 2,500 washes. Under the lifetime an average machine requires 2 repairs. Together with the initial investment and costs for electricity, water, detergents and repairs, one wash cost on average $US 1. The largest cots item is depreciation and repairs (around $US 0.5). Electricity and water costs about $US 0.25 and detergent – $US 0.27 Konsumentverket (2004). *Marknadsöversikt. Tvättmaskiner 2004 [Market review. Washing machines 2004]*. Stockholm, Konsumentverket**:** 29.

provide added utility to consumer for the lower accessibility to the machines. This could be in form of coffee rooms and/or appealing design of facilities.

Information about a service solution is crucial in order to compete with product alternatives. Product marketing schemes have been developing for decades and the pressure of marketing is enormous, which makes it difficult for the service alternatives to compete. It is very often that different service alternatives are advertised far less aggressively than products. At least until now, potential service users are not actively searching for services (Halme et al. 2003).

However, not only marketing pressure put a threat to service solutions. More and more proprietary services, which used to be delivered by skilled professionals, are gradually penetrating into the households and are being carried out by ordinary people as a self-service. Improvements in technology that make products cheaper and easier to operate, as well as increasing labour costs of hired service providers are the main reasons facilitating this process. This makes it more cost-effective for households to acquire a product and then spend their own time in generating household services. In these cases consumer time is often perceived as a free commodity, which leads to less free time and results in many social and psychological problems.

Conclusions

Households are mini-centres of consumption where lifestyles, cultures, habits and consumption patterns are formed and played out. They also have an important role in reducing consumption-related environmental impacts. Product servicising was suggested as one of the ways to reduce household-related environmental impacts and household-related services play an important role in product servicing.

Comparing the environmental soundness of community-based washing services and household-based washing in terms of energy and water consumption showed that assuming the same behaviour in both cases, public washing facilities have lower resource consumption, which stems from high performance characteristics of the installed equipment. The savings are substantial on a national scale, since according to our estimates the share of Swedish households that are using public washing services, which is about 35-40% of all families. Therefore, the total annual saving on the national level from using shared washing facilities is in the area of 200 GWh of electricity.

However, behavioural aspects are very important in determining the environmental soundness of service solutions. The main behavioural factors determining the outcomes are the load rate of laundry equipment and the choice of washing programmes. In cases where the service is provided for free (which is very common in community-owned launderettes), the environmental effects could be adverse. Knowledge and skills in operating the equipment is another important factor regardless the scenario of washing services. Many users operate washing equipment sub-optimally and for example in the case of washing centres, energy savings could be even larger if the laundry services would be provided by professionals and/or the users would be better informed about optimisation possibilities of their washing operations.

Factors that are most important for the success of the shift from product- to service-based model of consumption are rooted in cooperation between all relevant actors, who can optimise the system only with a combined effort. Although designing an environmentally superior infrastructure (including selection of environmentally advantageous products) is important, even more important is optimisation of consumer behaviour aspects. Consumer acceptance is another crucial factor for success as well as long-term viability of servicised solutions. This is only possible when economic and social demands are fulfilled at least to the degree, which product-based solutions can deliver. Successful services will be those, which will be able to offer more consumer utility at lower cost and with lower environmental impacts.

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